THE TELEGRAPHIC JOURNAL.

VOL. III.—No. 68.

PNEUMATIC TELEGRAPHY.

PNEUMATIC TELEGRAPHY has become quite an institution of the age. Scarcely a capital in Europe has failed to avail itself of its facilities to complete its telegraphic system. When stations lie together, close and thick, it is manifestly advantageous to connect them by mechanical means, so as to save, by the transport of the actual telegrams themselves, the multiplication of wires, apparatus, and clerks; and especially so when this can be done with a rapidity equal to that of telegraphy itself. Messages cannot be manipulated or written out at a greater rapidity than forty words per minute, so that if it is possible to transport a telegram itself from one place to another in a minute, not only is speed of transmission obtained but all sources of error are eliminated. In fact the average initial delay occupied by messages on the shortest lines is about five minutes, so that tubes which can convey the messages bodily within this limit are economical and beneficial. The essential element of telegraphy is speed of transmission, and it is evident that when currents of air can produce greater despatch than currents of electricity pneumatic tubes are preferable to wires. But apart from the question of speed of transmission tubes are essentially economical in the employment of staff, for their use reduces the number of clerks required to a minimum. But of course there is a limit to their useful employment, and a point is reached when, from telegraphic and economical grounds, wires surpass tubes in efficiency and desirability. The limit of length is about two miles, for at this distance telegrams exceed the five minutes interval allowed for their average transmission. Of course where rapidity is of no consequence this distance can be much exceeded, but, fortunately for the British public, the one criterion which its telegraphists have always endeavoured to attain, especially since the transfer of its telegraphs to the State, has been swiftness of transmission, and it is to swiftness more than to any reduction in price that the marvellous increase of business is due. In five years telegrams in England have increased from six millions to twenty millions.

The first germ of pneumatic telegraphy was sown in the year 1810, when Mr. George Medhurst (who, because he lived in *Denmark-street, Soho*, has always been called a Danish engineer) proposed and patented "a new method of conveying letters and goods with great certainty and rapidity by *air*." His proposal is so clear and interesting that it deserves extracting:—

"If a light and hollow vessel is so formed as to fill the area of a tube, and to move freely through it, carrying papers not exceeding three ounces in weight, it will be driven through the tube with the velocity of 150 feet in a second by the pressure of nine ounces per square inch.

"And therefore a tube of uniform dimensions being laid upon or under ground, from one place to another, without any sudden curvature, will form the means of conveying packets of letters with the velocity of 100 miles per hour, by forcing the air through the tube with a pressure of three ounces per square inch for every ounce weight in motion.

"And if there are two tubes of the same dimensions leading from one place to another, packets of letters may be conveyed each way, at the same time, without a possibility of their clashing against each other; and many packets may be conveyed the same way, in the same tube, which can never approach each other, but will all proceed with an uniform motion and equal rapidity to their destination, where, the tube entering an air-tight room, the packets will be deposited, and may be delivered or forwarded to the next stage through their proper tubes, commencing in the same room, and their progress can never be impeded by the seasons or the elements."—P. 6-7.

This proposal did not take practical form until 1854, when Mr. Latimer Clark laid down a 1½ inch lead pipe between the Electric Telegraph Company's Central Station, Lothbury (LY), and the Stock Exchange. An engine exhausted a receiver at LY, and carriers containing the messages were sucked through from the Stock Exchange. The traffic was only required to flow in one direction. In 1858, the system was extended to Mincing Lane, and about 1860 Mr. Varley introduced the use of compressed air, so that messages were drawn in one direction by a vacuum, and propelled in the other direction by a prenum. Mr. Clark had previously used a vacuum to work in both directions, a receiver at Mincing Lane having been exhausted by the engine at LY, by means of a special pipe laid down in the same trench with the carrier tube.

In 1865 the system was introduced in Paris. Considerable modifications were made in its mode of working. Compressed air was used entirely, and the necessary pressure was obtained by admitting water from the mains into large air reservoirs. This tube served several stations, which were worked intermediately, like a line of railway, or a telegraph current, each station having its own store of power to propel or forward the carrier on to the next place. This mode of ob-

taining power was found wasteful and expensive, and it has been nearly entirely abandoned in favour of steam working at one end of the circuit.

About the same period (1865), a system was introduced in Berlin by Messrs. Siemens, who used two pipes, laid in the same trench, between the Telegraph Station and the Bourse, arranged in a circuit, through which a continuous current of air was always kept flowing in the same direction by a double acting air pump, worked by a steam engine. This last mode of working was tried in London, but it has not proved successful, and it has been abandoned.

It will be seen how closely this system of Siemens' resembles that of Medhurst, and how curiously history works in a circle, for the vision of 1810 has become the stern fact of 1875. In all the places named the pneumatic telegraph has received considerable extension, and it has also been largely introduced in Vienna, where the Parisian system has been adopted.

ON WHEATSTONE'S ELECTRIC TELEGRAPH IN RELATION TO SCIENCE.

(Being an argument in favour of the full recognition of Science as a branch of Education.)

A Lecture delivered at the Royal Institution of Great Britain, on Friday, June 11th, 1858.

By Professor Faraday, D.C.L., F.R.S.*

The development of the application of physical science in modern times has become so large and so essential to the well-being of man that it may justly be used, as illustrating the true character of pure science, as a department of knowledge, and the claims it may have for consideration by governments, universities, and all bodies to whom is confided the fostering care and direction of learning. As a branch of learning, men are beginning to recognize the right of science to its own particular place;—for, though flowing in channels utterly different in their course and end to those of literature, it conduces not less, as a means of instruction, to the discipline of the mind; whilst it ministers, more or less, to the wants, comforts, and proper pleasure, both mental and bodily, of every individual of every class in life. Until of late years, the education for, and recognition of it, by the bodies which may be considered as governing the general course of all education, has been chiefly directed to it only as it could serve professional services,—namely, those which are remunerated by society; but now the fitness of university degrees in science is under consideration, and many are taking a high view of it, as distinguished from literature, and think that it may well be studied for its own sake, *i.e.* as a proper exercise of the human intelligence, able to bring into action and development all the powers of the mind. As a branch of learning, it has (without reference to its applications) become as extensive and varied as literature; and it has this privilege, that it must ever go on increasing. Thus it becomes a duty to foster, direct, and honour it, as literature is so guided and recognized; and the duty is the more imperative, as we find, by the unguided progress of science and the experience it supplies, that of those men who devote themselves to studious education, there are so many whose minds are constitutionally disposed to the studies supplied by it, as there are of others more fitted by inclination and power to pursue literature.

The value of the public recognition of science as a leading branch of education, may be estimated, in a very considerable degree, by observation of the results of the education which it has obtained incidentally from those, who pursuing it, have educated themselves. Though men may be especially fitted by the nature of their minds for the attainment and advance of literature, science, or the fine arts, all these men, and all others, require first to be educated in that which is known in these respective mental paths; and when they go beyond this preliminary teaching, they require a self-education directed (at least in science) to the highest reasoning power of the mind. Any part of pure science may be selected to show how much this private self-teaching has done, and, by that, to aid the present movement in favour of the recognition generally of scientific education in an equal degree with that which is literary; but perhaps electricity, as being the portion which has been left most to its own development, and has produced as its results the most enduring marks on the face of the globe, may be referred to. In 1800, Volta discovered the voltaic pile; giving a source and form of electricity before unknown. It was not an accident, but resulted from his mental self-education: it was at first a feeble instrument, giving feeble results; but by the united mental exertions of other men, who educated themselves through the force of thought and experiment, it has been raised up to such a degree of power as to give us light, and heat, and magnetic and chemical action, in states more exalted than those supplied by any other means.

In 1819, Oersted discovered the magnetism of the electric current and its relation to the magnetic needle; and as an immediate consequence, other men, as Arago and Davy, instructing themselves by the partial laws and action of the bodies concerned, magnetised iron by the current. The results were so feeble at first as to be scarcely visible; but, by the exertion of self-taught men, since then, they have been exalted so highly as to give us magnets of a force unimaginable in former times.

In 1831, the induction of electrical currents one by another, and the evolution from magnets was observed,—at first in results so small and feeble, that it required one much instructed in the pursuit, to perceive and lay hold of them; but these feeble results, taken into the minds of men already partially educated and ever proceeding onwards in their self-education, have so developed, as to supply sources of electricity independent of the voltaic battery or the electric machine, yet having the power of both, combined in a manner and degree which they, neither separate nor together, could ever have given it, and applicable to all the practical electrical purposes of life.

To consider all the departments of electricity

* We have much pleasure in repainting this just tribute from one great man to another great man.

fully, would be to lose the argument for its fitness in subserving education, in the vastness of its extent; and it will be better to confine the attention to one application, as the electric telegraph, and even to one small part of that application, in the present case. Thoughts of an electric telegraph came over the minds of those who had been instructed in the nature of electricity as soon as the conduction of that power with extreme swiftness through metals was known, and grew as the knowledge of that branch of science increased. The thought, as realized at the present day, includes a wonderful amount of study and development. As the end in view presented itself more and more distinctly, points at first apparently of no consequence to the knowledge of the science generally, rose into an importance which obtained for them the most careful culture and examination, and the almost exclusive exercise of minds whose powers of judgment and reasoning had been raised first by general education, and who, in addition, had acquired the special kind of education which the science in its previous state could give. Numerous and important as the points are which have been already recognised, others are continually coming into sight as the great development proceeds, and with a rapidity such as to make us believe that much as there is known to us, the unknown far exceeds it; and that extensive as is the teaching of method, facts, and law, which can be established at present, an education looking for far greater results should be favoured and directed.

The results already obtained are so large, as even in money value to be of very great importance; —as regards their higher influence upon the human mind, especially when that is considered in respect of cultivation, I trust they are, and ever will be, far greater. No intention exists here of comparing one telegraph with another, or of assigning their respective dates, merits or special uses. Those of Mr. Wheatstone are selected for the visible illustration of a brief argument in favour of a large public recognition of scientific education, because he is a man both of science and practice, and was one of the very earliest in the field, and because certain large steps in the course of his telegraphic life will tell upon the general argument. Without referring to what he had done previously, it may be observed that in 1840 he took out patents for electric telegraphs, which included, amongst other things, the use of the electricity from magnets at the communicator, the dial-face,—the step-by-step motion,—and the electro magnet at the indicator. [At the present time, 1858, he has taken out patents for instruments containing all these points; but these instruments are so altered and varied in character above and beyond the former, that an untaught person could not recognise them.] The changes may be considered as the result of education upon the one mind which has been concerned with them, and are to me strong illustrations of the effects which general scientific education may be expected to produce.*

In the first instruments powerful magnets were used, and keepers with heavy coils associated with them. When magnetic electricity was first discovered, the signs were feeble, and the mind of the student was led to increase the results by increasing the force and size of the instruments. When the object was to obtain a current sufficient to give signals through long circuits, large apparatus were employed, but these involved the inconveniences of inertia and momentum; the keeper was not set in motion at once, nor instantly stopped; and, if connected directly with the reading indices, these circumstances caused an occasional uncertainty of action. Prepared by its previous education, the mind could perceive the disadvantages of these influences, and could proceed to their removal; and now a small magnet is used to send sufficient currents through 12, 20, 50, a hundred, or several hundred miles; a keeper and helix is associated with it, which the hand can easily put in motion; and the currents are not sent out of the indicating instrument to tell their story, until a key is depressed, and thus irregularity contingent upon the first action is removed. A small magnet, ever ready for action and never wasting, can replace the voltaic battery; if powerful agencies be required, the electro-magnet can be employed without any change in principle or telegraphic practice; and as magneto-electric currents have special advantages over voltaic currents, these are in every case retained. These advantages I consider as the results of scientific education, much of it not tutorial, but of self; but there is a special privilege about the science-branch of education, namely, that what is personal in the first instance immediately becomes an addition to the stock of scientific learning, and passes into the hands of the tutor, to be used by him in the education of others, and enable them in turn to educate themselves. How well may the young man entering upon his studies in electricity be taught by what is past to watch for the smallest signs of action, new or old; to nurse them up by any means until they have gained strength; then to study their laws, to eliminate the essential conditions from the non-essential, and at last, to refine again, until the encumbering matter is as much as possible dismissed, and the power left in its highly developed and most exalted state.

The alternations or successions of currents produced by the movement of the keeper at the communicator, pass along the wire to the indicator at a distance; there each one for itself confers a magnetic condition on a piece of soft iron, and renders it attractive or repulsive of small permanent magnets; and these acting in turn on a propelment, cause the index to pass at will from one letter to another on the dial face. The first electro-magnets, *i.e.*, those made by the circulation of an electric current round a piece of soft iron, were weak; they were quickly strengthened, and it was only when they were strong that their laws and actions could be successfully investigated. But now they were required small, yet powerful. Then came the teaching of Ohm's law; and it was only by patient study under such teaching that Wheatstone was able so to refine the little electro-magnets at the indicator that they should be small enough to consist with the fine work there employed, able to do their appointed work when excited in contrary directions by the brief currents flowing from the original common magnet, and unobjectionable in respect of any resistance they might offer to the transit of these tell-tale currents.

* The former and the present apparatus were set to work in illustration of the points as they were noticed.

These small transitory electro-magnets attract and repel certain permanent magnetic needles, and the to-and-fro motion of the latter is communicated by a propelment to the index, being there converted into a step-by-step motion. Here everything is of the finest workmanship; the propelment itself requires to be watched by a lens, if its action is to be observed; the parts never leave hold of each other; the vibratory or rotatory ratchet wheel and the fixed pallets are always touching, and thus allow of no detachment or loose shake; the holes of the axes are jewelled; the moving parts are most carefully balanced, a consequence of which is that agitation of the whole does not disturb the parts, and the telegraph works just as well when it is twisted about in the hands, or placed on board a ship or in a railway carriage, as when fixed immovably. Where it is possible, as in the vibratory needle, the moving parts are brought near to the centre of the motion, that the inertia of the portion to be moved, or the momentum of that to be stopped, should be as small as possible, and thus great quickness of indication obtained. All this delicacy of arrangement and workmanship is introduced advisedly; for the inventor, whom I may call the student here, considers that refined and perfect workmanship is more exact in its action, more unchangeable by time and use, and more enduring in its existence, than that which, being heavier, must be coarser in its workmanship, less regular in its action, and less fitted for the application of force by fine electric currents.

Now there was no chance in the course of these developments;—if there were experiments, they were directed by the previously acquired knowledge;—every part of the investigations was made and guided by the instructed mind. The results being such (and like illustrations might be drawn from other men's telegraphs or from other departments of electrical science), then, if the term education may be understood in so large a sense as to include all that belongs to the improvement of the mind, either by the acquisition of the knowledge of others, or by increase of it through its own exertions, we learn by them what is the kind of education science offers to man. It teaches us to be *neglectful* of nothing; not to despise the small beginnings, for they precede of necessity all great things in the knowledge of science, either pure or applied. It teaches a continual comparison of the *small and great* and that under differences almost approaching the infinite; for the small as often contains the great in principle as the great does the small; and thus the mind becomes comprehensive. It teaches us to deduce principles carefully, to hold them firmly, or to suspend the judgment: to discover and obey *law*, and by it to be bold in applying to the greatest what we know of the smallest. It teaches us first, by tutors and books, to learn that which is already known to others, and then, by the light and methods which belong to science, to learn for ourselves and for others;—so making a fruitful return to man in the future for that which we have obtained from the men of the past. Bacon, in his instruction, tells us that the scientific student ought not to be as the ant who gathers merely, nor as the spider who spins from her own bowels, but rather as the bee, who both gathers and produces.

All this is true of the teaching afforded by any part of physical science. Electricity is often called wonderful—beautiful; but it is so only in common with the other forces of nature. The beauty of electricity, or of any other force, is not that the power is mysterious and unexpected, touching every sense at unawares in turn, but that it is under *law*, and that the taught intellect can even now govern it largely. The human mind is placed above, not beneath it; and it is in such a point of view that the mental education afforded by science is rendered supereminent in dignity, in practical application, and utility; for, by enabling the mind to apply the natural power through law, it conveys the gifts of God to man.

SECONDARY BATTERIES OF M. PLANTE.

By A. NIAUDET-BREGUET.

Secondary currents, or currents of polarisation, have formed the subject of numerous researches ever since the period when they were discovered, that is to say, since the commencement of the present century; but it is only within the last few years that it has been ascertained that they are capable of being applied to purposes of practical utility.

During the last fifteen years M. Gaston Planté has been engaged upon the investigation of this subject, and, by continuous efforts and by successive stages of progress, he has arrived at results of the greatest interest—results of the nature of which we shall now endeavour to give an idea.

The reader knows that the Voltameter is an instrument in which water is decomposed by the current from an ordinary galvanic battery; in fig. 1 is represented one of the fundamental experiments in Physics. At the exact instant when the Voltameter has been just subjected to the action of the battery, it may be regarded as a secondary couple or element; if the two electrodes are now connected with the wire of a galvanometer the needle of the latter will be deflected during several seconds, and will show the passage of a current which grows gradually weaker and becomes imperceptible after a somewhat short space of time. This current is what is called a secondary current; it has been supplied by the battery to the Voltameter, and it is given back again by the latter.

M. Planté showed, as early as 1859, that lead is the most suitable metal for employment in secondary batteries, and he has, since that time, still further confirmed the superiority of this metal. Fig. 2 shows a secondary element as now constructed. In a tall vessel of glass, guttapercha, or ebonite, are placed two sheets of lead, rolled spirally, and parallel one to the other, and kept from touching by two cords of indiarubber rolled up with them; these two sheets of lead are immersed in a solution of one part of sulphuric acid to nine parts of water. The vessel is closed by a sealed cover pierced with a small hole, through which the liquid can be poured in or extracted, and which also allows the escape of any gas which may be generated during the charging of the battery. The apparatus is surmounted by a disc of ebonite, upon which are fixed two contact pieces in connection with the two electrodes; two

clips are also provided for the purpose of holding metallic wires to be made red hot or melted by the secondary current.

Two Bunsen cells or, in their stead, three Daniell cells are required to charge this secondary element. During the operation of charging one of the electrodes oxydizes, a brown coating of peroxide of lead soon shows itself, and the metallic appearance disappears entirely; the other electrode also changes in appearance, its surface becomes covered with a powdery grey coating.

When the charge has attained its maximum, that is to say, when oxygen commences to be given off by the brown electrode, it is well to disconnect the secondary element from the charging battery, for any further expenditure of the polarising current is entirely wasted.

The secondary element once charged in this manner and left to itself will retain a portion of its charge for several days; and even at the end of a week it is still far from being exhausted.

The secondary element, when fully charged, has an electro-motive force equal to one and a half times that of a Bunsen; it will redden a platinum wire of a greater or lesser diameter according to its size, or rather according to the size of the electrodes; for it is of course understood that the quantity of electricity which the apparatus will furnish is in proportion to the extent of leaden surface subjected to the action of the polarising current and covered with an active electro-chemical deposit.

It should be remarked that the particular (spiral) form of the electrodes gives an element having a large surface and a small resistance within a small space, so that one of Plantés secondary elements is equal to an active or ordinary element of a very unusual size; the small pattern has an active surface of 8 square decimetres (124 square inches), the large pattern a surface of 40 square decimetres (620 square inches).

The current furnished by the secondary element will effect chemical decomposition, act upon an electro-magnet, &c.; but if its intensity is measured by any of the ordinary methods, as, for example, by means of a galvanometer, it will be found to decrease gradually from the maximum spoken of above. This diminution is rather slow if the circuit has a large resistance, and if, in consequence, the electricity passes in small quantity; but it is, on the contrary, very rapid if the circuit is one of but small resistance, because the electricity then flows in large quantity.

The period of discharge gives rise to an interesting observation. The battery is to all appearance completely discharged, but if it is allowed to rest for a few minutes with the circuit disconnected, it is found to have reacquired a certain amount of force, and is able again to give forth a certain quantity of electricity. The battery being then discharged of the first *residuum*, and again left to itself for a short time, will give a second *residuum* smaller, indeed, than the first. The latter will not be the last; several other charges can still be obtained.

M. Planté has very clearly explained this peculiarity. The secondary element when it comes into action is discharged, and is at the same time polarized, as in the case of batteries with a single fluid. This polarization acquires after a certain time a power almost equal to that of the weakened secondary element, and the action then ceases or becomes very slight. If the battery is now allowed to rest it depolarizes itself, as happens in the case of all single fluid batteries polarized by their own action; the battery, once depolarized, is then again ready to give forth a current, but in the next discharge it becomes polarized afresh and so on.

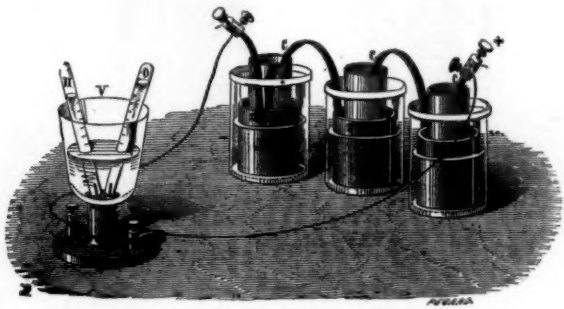

FIG. 1.—*Voltameter and Daniell battery.*

Let us now suppose that the secondary element has been entirely discharged or nearly so, it can be recharged by means of the two Bunsen elements as at first; but it is worthy of notice that a fresh charge is communicated all the more quickly as the operation is performed more promptly after the discharge.

Moreover, a secondary element is all the better for having been charged and discharged a greater number of times; at first, when it is almost new, there is an advantage in polarizing the electrodes, sometimes in one direction and sometimes in the other, reversing several times the direction of the charge; but when the element is formed the greatest care must, on the contrary, be taken to charge it always in the same direction. If this precaution is neglected the time required for charging will be much increased, for the oxide of lead which may happen to remain upon one of the electrodes must be reduced and the plate, previously negative, must be oxydized. But after this operation the secondary element regains all its power and may even be said to be all the better for it.

Figure 3 shows a peculiar form in which M. Planté has arranged the secondary element, and to which he has given the name of *Briquet de Saturne* (Saturn's tinder-box). On the upper part of the box may be seen two small clips, between which

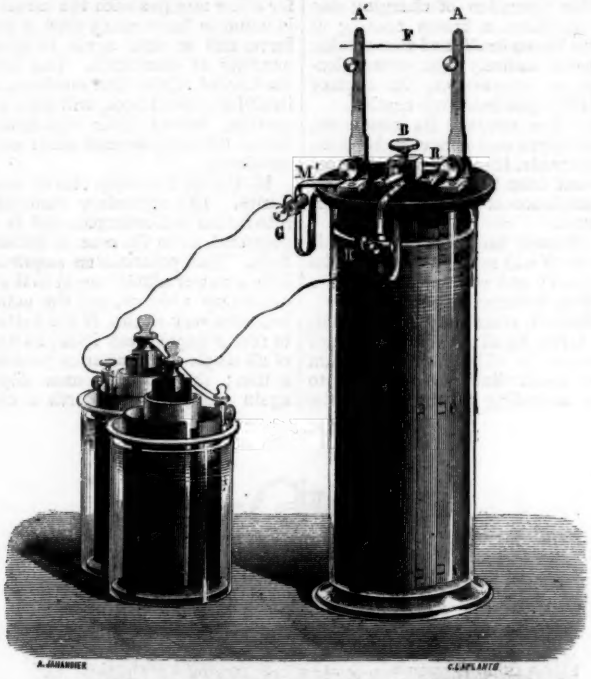

FIG. 2.—*Two Bunsen elements charging a secondary element.*

s stretched a platinum wire; every time that, by pressing with the finger, the two springs at the bottom of the box are brought in contact, the battery sends a current through the platinum wire heating it to redness, the taper is then lighted almost instantaneously. With an apparatus of

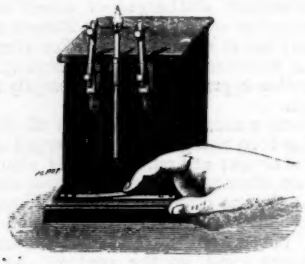

FIG. 3.

this kind well charged the taper may be lighted one hundred times, and it is only after being used this large number of times that it is necessary to recharge with three Daniell elements. Thus we have a new means of obtaining fire and a very economical one, for the secondary element itself consumes nothing and the charging battery merely a few grammes of sulphate of copper for supplying the apparatus during a very long period.

The same apparatus might be employed either in civil or military engineering for exploding mines; it has been shown by experiment that with fuses of rather fine platinum wire (one-twentieth of a millimetre in diameter), an explosion can be produced through a copper wire 900 metres in length and three millimetres in diameter.

With an apparatus of a similar kind, surgeons are enabled to cauterize a wound, and this application has already been often brought into practical use; a secondary element is much more easily carried into an hospital, and especially into the house of a patient, than the active elements which it is capable of replacing.

These secondary elements can be joined together, either for intensity or for quantity, and they form batteries capable of producing all the effects of batteries of the ordinary form, and of the most powerful kind. Figure 4 represents a secondary battery as arranged by M. Planté, and such as would render the most valuable service in a variety of applications.

The number and size of the couples require to be varied, in order to obtain given effects of tension and quantity. Here, we have twenty elements arranged in two rows; at the upper part is an ingeniously contrived commutator, so arranged that in one position it joins all the elements together for quantity, and in another, at right angles with the first, it groups them for intensity. In the first

position all the outer electrodes are joined to one metallic bar, and all the inner electrodes to another similar bar, so that the whole apparatus is equivalent to a single element of very large surface; it is whilst in this position that the secondary battery is charged; two Bunsen elements are sufficient to effect a complete charge, the time occupied being longer or shorter according to the size of the charging cells and the extent of the leaden surface to be polarized. In the second position of the commutator, the exterior electrode of each element is connected to the interior electrode of the next element, and the apparatus becomes a real battery of twenty cells; it is whilst connected in this manner that the battery is discharged; the power at the beginning of the discharge is equal to thirty Bunsen elements of very large surface.

As the discharge proceeds, the tension falls, as we have explained when speaking of the single secondary element. If one minute has been the time occupied in charging the secondary battery, joining all the fuses as branches out of a single wire, and discharging a secondary battery into all of them simultaneously. This plan is a very economical one; there is no doubt that it involves much less labour and cost to set up two Bunsen elements and charge the secondary battery than to charge the twenty or thirty Bunsen elements whose place is supplied; it being of course understood that the work is required from the battery during but a few seconds, and that the operation is repeated but four or five times in the course of the day. Moreover, the secondary battery can be easily carried about to the different workshops where the works extend over a considerable area, as during the construction of a long tunnel or the sinking of shafts for mines.

In small laboratories the expense of setting up a large Bunsen battery is an obstacle to the carrying out of certain experiments, either for demonstration to pupils or for the investigations and researches of the teacher. The greater number of

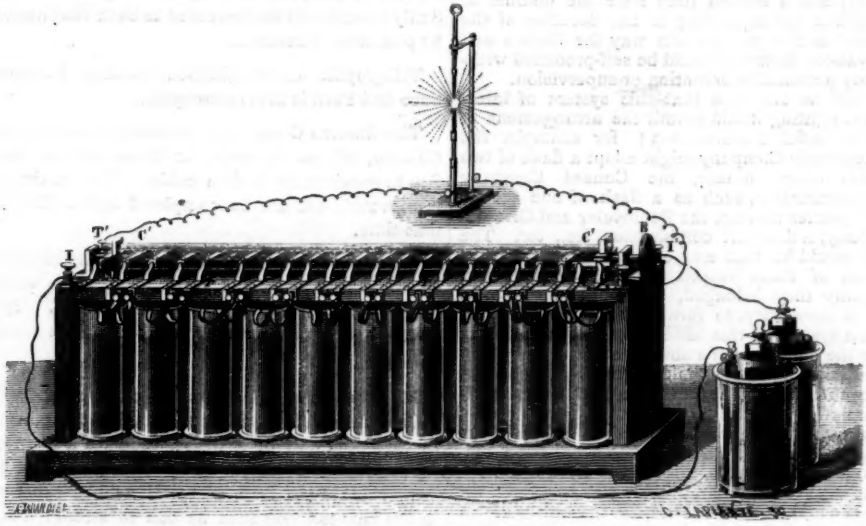

FIG. 4.—*Secondary Battery of twenty elements capable of being charged with two Bunsen elements when arranged for quantity, and producing light upon being discharged with intensity connections.*

in quantity, from the two Bunsen elements, it cannot be expected that the discharge, in intensity, will produce the effect of thirty Bunsen elements of the same size during more than four seconds, for the apparatus does not produce electricity, and can only transform that which is imparted to it. M. Planté has made exact experiments upon this point, and has found that in the transformation about one-tenth part is lost, or, in other terms, that the apparatus gives back nine-tenths of what has been expended.

It is easily perceived that the secondary battery can only produce effects of short duration, but in a very great number of cases such effects are all that is required.

If, for example, it is desired to explode simultaneously a large number of mines by means of fuses of fine wire, the object can be attained by these experiments become possible by the use of the Planté battery. If, finally, this apparatus is used in combination with a Gramme machine instead of an ordinary battery, all handling of acids is got rid of as well as all other expense except the purchase of the apparatus, which will last an indefinite time.

We have the greatest confidence in the future of this combined employment of the secondary battery and the Gramme machine, and we shall show in conclusion how it furnishes a solution to the important problem of lighting ships with a view to the avoidance of collisions at sea.

It is not by any means necessary to exhibit at the top of the mainmast a permanent electro light; it will he enough to secure a vessel from collision if it gives warning of its presence around the horizon by a signal of two seconds duration shown once a

minute. Now an unintermittent light of this kind can be produced by a secondary battery alternately charged and discharged; charged from a Gramme machine during fifty-eight seconds and discharged during the remaining two seconds. Upon steamers, which it is specialiy necessary should be well lighted, the engines will work the Gramme machine and the electric light will, as a fact, have its origin in the fuel which heats the boilers. Upon large sailing vessels an electric light would also be found useful, at least on foggy nights. In order to produce it, all that is necessary is to add to the arrangement of which we have spoken an apparatus, by means of which a sailor working alternately two pedals would turn a Gramme machine, and thus produce the exciting current for the secondary battery.

In both cases the movement of the commutator of the battery could be effected automatically after the completion of the number of revolutions of the Gramme machine required to charge the battery, and a second time after the number of revolutions corresponding to the duration of the effective discharge. In this way the flashes and intervals of darkness would be self-produced without any personal intervention or supervision.

It will be observed that this system of intermittent lighting would permit the arrangement of certain useful combinations; for example, the Transatlantic Company might adopt a flash of two seconds every minute, the Cunard Company another variation, such as a flash of one second every quarter minute, the Peninsular and Oriental Company, a different combination, &c., &c. The result would be that any one coming within the horizon of these vessels would know to which Company they belonged, and would be able, in case of necesstity, to furnish useful information. With a system of this kind it would be easier to know the character of a ship by night than by day. A ship in distress should signal by a peculiar arrangement of flashes, to be adopted by vessels of all nations, and to be understood by all; such a signal would be more distinct than the firing of guns or blowing of whistles, which are often rendered inaudible by the noise of the storm. Lastly, in the case of a squadron sailing in company, the flashes could be used to transmit the orders of the chief commander to the commanders of the other vessels; the alphabets at present in use could be easily transformed and adapted to this new means of communication.

We may add that the proposed combination is applicable to the transmission of signals between different points in a besieged place, or of large entrenched camps such as it is proposed to establish for the defence of the French territory; it would also enable those besieged to communicate with very distant points not occupied by the enemy.

Notes.

THE annual soirée of the President of the Society of Telegraph Engineers has been definitely fixed for Tuesday, the 21st December. It will be held at Willis' Rooms. The election of president and officers of the society will take place at the annual general meeting, to be held on Wednesday, the 8th December.

The German Union and the Dunkirk-Denmark cables are interrupted.

Many officers of the old Electric Telegraph Company will learn with regret that Mr. George Cox was buried in Putney on November 17th. He was for many years Superintendent of the South-Western District of that Company, and resided at Southampton. He retired from the telegraph service in 1856. Mr. W. H. Evans, also for many years Superintendent of the Scotch District, died at Oswestry on the 8th inst.

Telegrahic communication by the cable between Penzance and the Scilly Islands is interrupted. During the interruption telegrams for the Scilly Islands will be forwarded to their destination by post from Penzance.

Telegraphic communication between Pernambuco and Para is also interrupted.

The Eastern Company's repairing steamer, the *Chiltern*, left on the 20th for Suez and the Red Sea to repair their broken cable. The repairs, it is expected, will not be completed before Christmas time.

The *Agnes* is now engaged repairing the Madras-Penang cable, whilst the *Hawk* is about to effect some necessary repairs to the Lisbon cable. The *Caroline* is at work on the Dunkirk-Denmark cable, which is interrupted.

M. Planté has shown that a cloud of metallic matter detached from the electrode by a current of high potential in a liquid, assumes a gyratory movement when acted on by a magnet, and he suggests that the form of spiral nebulæ observed in the heavens may thus be due to strongly magnetic celestial bodies in their neighbourhood.

We learn that a professorship for the special teaching of telegraphy, both theoretical and practical, has just been established at the Polytechnic School in Dresden, and that Doctor and Professor K. Edward Zetzsche, who is well known to our readers as a contributor to this Journal, and the author of numerous publications upon telegraphy, has had the honour to be appointed to fill it. If, as there is reason to expect, this special teaching is attended with the success which the extension and importance of telegraphy ought to assure for it, there will probably arise the question of completing the plan by the subsequent formation, in this institution for higher education, of an independent section for the study of telegraphy under conditions similar to those which already exist for

the other branches of engineering. We cannot but wish the greatest success to an institution which comes forward to supply a deficiency, which has been for a long time felt, in higher education. —(*Journal Telegraphique.*)

M. Jules Sommati, of the the Italian Telegraph Administration, has proposed a new form of electro-magnet. He describes his invention in the following words :—" The molecular currents of the " soft iron of electro-magnets in a state of rest " have different directions, whose resultant is zero. " The passage of an electric current has the effect " of giving to these molecular currents a magnetic " direction. On the other hand, the numerous " experiments made by M. de Haldat have led " that physicist to the conclusion that the mag- " netization in electro-magnets is entirely super- " ficial. If, then, the number of molecules upon " which the current acts is increased, that is to " say, the lateral surface of the soft iron (other " conditions remaining the same), an augmenta- " tion of magnetic power will be obtained. Con- " sequently, with equal bulk, the form which gives " the greatest amount of lateral surface will be " the best for the cores of the electro-magnet. " Now, as a prism, whose section is an equilateral " triangle, is that form which gives the greatest " amount of lateral surface, there will be a real " advantage in substituting this prismatic form " for the cylindrical form whose lateral surface is " to that of a prism as 1 to 1·287, or nearly as 10 " to 13." M. Sommati has made and tried two electro magnets (equal in size and length, and surrounded by an equal number of convolutions of silk-covered copper wire), the cores of one being cylindrical, and those of the other prisms having their sections equilateral triangles, the edges being slightly rounded. The magnetic power of these two electro-magnets, measured by a balance on the Becquerel system, gave a very sppreciable difference in favour of the latter, the advantage being almost proportional to the surfaces of the cores.—(*Journal Telegraphique.*)

The following extracts are taken from the annual report of the Hon. W. Orton, President of the Western Union Telegraph Company :—

" The gross receipts for the year from all sources, except proceeds of bonds, were 9,564,574.60 dols. ; the gross expenses were 6,335,414.77 dols. ; the difference 3,229,159.83 dols. being net profit. All sums paid as rental for leased lines are included in the gross expenses.

" Compared with the preceding fiscal year, there was an increase in the gross receipts of 301,920.62 dols. ; a decrease in the expenses of 420,319.06 dols. ; and increase in the net profit of 722,239.68 dols.

" There were in operation at the end of the year 72.833 miles of line, 179,294 miles of wire, and 6,565 offices.

" The number of messages transmitted during the year was 17,153,710, being an increase of 824,454 over the preceding year.

" The Punta Rassa cable, which had been interrupted several times during the summer, involving a considerable loss of revenue, and extra expenses for temporary repairs, gave out entirely a few weeks ago, since when communication has been maintained by steamer. While this is being written, information has been received that the *Morse* has successfully laid the new cable, which is working perfectly, and that telegraphic communication with Key West and Havana has been restored.

" A fault has been discovered in the cable o 1869, between Key West and Havana, and although the use of this cable is not required for the present volume of traffic, the new and better cable of 1873 being capable of passing double the present number of messages, the *Morse* will proceed at once to discover and repair the fault. When this has been done, the other cable between Key West and Punta Rassa will be repaired, and when this is done the company will then have two lines of cable from Punta Rassa to Havana.

" The growth of the company's property and business during the nine years which have passed since the consolidation with the other principal telegraph lines is shown by the following statistics :— From 1867 to 1875 the extent of line has increased from 46,270 to 72,833 miles, and the wires from 85,290 to 179,294 miles, being an increase of 57 per cent. of line, and 110 per cent. of wire. The number of offices and stations has increased from 2,565 to 6,565, equal to 156 per cent. During the same time the number of messages transmitted has increased 192 per cent., the rate of tolls has decreased 51 per cent., and the gross receipts have increased 46 per cent. The average cost per message, during the same time, has been reduced from 67 to 37 cents. or about 45 per cent. The increase of 192 per cent. in the number of messages transmitted annually, while the mileage of wire has increased but 110 per cent., is explained by the fact that the number of messages transmitted per mile of wire has been increased 41 per cent.

" The ability to make so large an increase in the carrying capacity of the wires, is due in part to improvement in their conductivity and insulation, and in part to the introduction of the duplex and

quadruplex apparatus, by means of which one wire is made to do the ordinary work of two, three, or four wires. By means of this apparatus, during the past year, the company has had the use of more than 30,000 miles of what may be called 'phantom wire,' which has cost nothing to provide, repair, and maintain except the cost of the new apparatus, which is but little more expensive than that in general use, and is adapted to all ordinary purposes The cable steamer *Professor Morse* successfully completed the laying of the new cable of the International Ocean Telegraph Company between Key West and Punta Rassa on the 11th ult. Mr. Theophilus Smith, assistant to Sir Samuel Canning, the engineer employed to superintend the construction and laying of the cable, had charge of the work. The insulation of the new cable is excellent, tests showing a resistance of 360 megohms per knot."

The old Punta Rasa cable which had been interrupted as reported above, was successfully repairing. During the repairs, however, the pressure of " cable borers " was discovered.

The reports of the Italian Telegraph Service show that its development has very largely increased since 1861, when the present constitution of the empire was established. The following extracted statistical table of comparison will briefly show the increase :—

	1861. miles.	1873. miles.
Length of lines	4,971 ..	13,670
Length of wires	8,078 ..	43,497
Number of offices	225 ..	1,622
Number of instruments ..	400 ..	2,800
Government messages per annum	180,000 ..	300,000
Private messages per annm	600,000 ..	5,040,000

The Post Office announces the following,—

Information has been received from the Eastern Telegraph Company that telegrams for the undermentioned places in Peru can now be prepaid to their destination. The rates to be collected are (1) the rate to Valparaiso, £13 7s. 6d, for 20 words, or less, to which must be added (2) the following rates:—

	10 Words. £ s. d.		Each additional word. £ s. d.
Iquique - -	2 10 0	—	0 5 0
Arica - -	3 15 0	—	0 7 6
Islay & Mollinde	5 0 0	—	0 15 0

The following circular has been issued by the Direct United States Cable Company (Limited):

Palmerston Buildings, Old Broad Street,
London, E.C., Nov. 17.

Sir,—I am desired by the Board to inform you that the company's Ireland and Novia Scotia cable was repaired on the 5th of this month, and reopened for public traffic on the following day. Since that time our cables have been in excellent working order, and have been transmitting a fair share of Transatlantic telegrams. Before this interruption both cables were tested by me in Ireland, and I found the insulation perfect and the inductive capacity so low as to make a very high speed of transmission possible, whilst the conductivity exceeded my most favourable expectations. On the completion of my tests the contractors had our cables tested on their behalf by the eminent electrician, Sir William Thomson. From his very full report of his various and exhaustive tests, I quote the following passage:— " In conclusion, I am glad to be able to say that my tests proved the cable to be in perfect condition as to insulation, and showed its electrostatic capacity and copper resistance to be so small as to give it a power of transmitting messages, which, for a Transatlantic Cable of so great a length, is a very remarkable as well as valuable achievement." In addition to the favourable conclusion established by these tests, I may state that the specimens of the cable which have been picked up after a submersion of more than nine months from a depth of 2,240 fathoms, show the cable to be as perfect and as strong in every respect as it was when it left the works of the contractors. This company's cables are thus not only electrically, but also mechanically in the most perfect condition, and now possess in all respects the same high standard that they had previous to the late interruption. The expectations of this company that a great efficiency would be obtained in transmitting messages have been fully realised, as more than once telegrams handed in at the London office of this company were delivered to the addresses at New York within four minutes of the time of their receipt. The traffic, which may be said to be only now developing, has made a very satisfactory beginning. Customers are daily increasing, and in a few days this company will open an office in Liverpool for Transatlantic messages, which will be sent direct over a special wire to Ireland to their ultimate destinations. Looking at the interest which you naturally take in the prosperity of this company, I venture to ask you, not only to send your own messages to America over this company's cables, but also, if possible, to obtain the custom of your friends. A decided advantage offered by this company consists in the line being worked between London, Liverpool, and New York by this Company's own staff, thus insuring perfect uniformity in the mode of working, and in the maintenance of discipline in all the company's

stations, and thereby eliminating all the inconveniences of handing over messages between those places from one administration to another.—I am, sir, your obedient servant,

G. VON CHAUVIN, Managing Director.

Proceedings of Societies.

THE SOCIETY OF TELEGRAPH ENGINEERS.

AN ordinary general meeting was held on Wednesday, the 24th November, Professor ABEL, F.R.S., Vice-President, in the chair.

After the ordinary business eleven new candidates were proposed.

The adjourned discussion on the "Durability of Guttapercha and Indiarubber Joints" was resumed by Mr. WARREN, who spoke of the care required in making Indiarubber joints.

Messrs. BELL and PREECE entered into descriptions of the new paraffin joint for street work, which, although not successful up to the present time, had, by the nature of the defects, given sufficient indication that the removal of those defects would result in a valuable joint for the future. The joint is ordinarily made by passing the guttapercha wires through two holes bored in a small oval-shaped piece of wood, the ends of the copper wire are then twisted and soldered; over this is placed a zinc tube, which fits the wooden base, into this melted paraffin is poured and the joint is complete. Joints made eighteen months ago still tested perfect.

The discussion was continued and a description given by Captain McEVOY of the mechanical joint used for torpedo cables.

The discussion was concluded with a vote of thanks to Mr. HENRY MANCE, the author.

A paper was then read, of which the following is an abstract:—

Experiments conducted for the purpose of ascertaining whether the teredo borer prefers guttapercha to indiarubber.—*By* HENRY MANCE.

Having received instructions in 1874 to submerge some pieces of cable in the Kurrachee Harbour to ascertain, if possible, whether indiarubber was as liable to the attacks of borers as guttapercha, the following experiments were made by me for the purpose of obtaining the desired information.

The pieces laid in the harbour for trial were as follows:—

1 length of bare guttapercha core.
1 length of bare indiarubber core.
1 length of Persian Gulf guttapercha cable.
1 length of Persian Gulf indiarubber cable.

One of the sheathing-wires had been removed throughout from each of the pieces of cable. The length of each piece was nearly 200 yards, and they all tested good before submersion. They were laid in the immediate vicinity of each other, and, to make the conditions of trial as equal as possible, the bare percha core was lashed alongside the piece of guttapercha cable; the bare indiarubber core was also lashed to the indiarubber cable.

On recovery after a submersion of nearly ten months, the only piece which tested good was the length of indiarubber cable; the other three were bad from the following causes:—

The core of the guttapercha cable was riddled by borers, the conductor being exposed in most cases; there were probably a hundred perforations in this piece.

The length of bare guttapercha core laid alongside the foregoing piece had but *five* borer holes in it; it was otherwise uninjured, as the barnacles grow *round* guttapercha core, adapting themselves to the form of the core without cutting into it to any dangerous extent.

The piece of bare indiarubber core had not a single borer perforation, but was found to contain a number of very remarkable faults towards the end which had rested in shallow water. The rubber was notched as neatly and regularly as if the injury had been done with a sharp knife, but in a few instances the piece of indiarubber was found remaining in the notch. the conductor being in nearly every case exposed. In the neighbourhood of these faults the core was thickly covered with barnacles, and it is possible that these peculiar injuries have been caused by some marine animal feeding on the barnacles which attach themselves to the core. The barnacles adhere so tightly to indiarubber that it would be difficult for a marine animal to remove them without tearing away a portion ot the rubber.

Bare indiarubber core is more susceptible to injury from barnacles than bare guttapercha. As the barnacle grows the base of the shell cuts into the yielding rubber, a second shell attaches itself to the side of the first, the growth of the circumference proceeds towards the conductor, and eventually the sharp edge of one of the cluster reaches the copper wire.

The piece of indiarubber cable tested perfect; but on examination, after stripping off the guards, about a dozen marks were discovered, showing that the borers had been at work. In no case, however, had the teredo succeeded in penetrating to the conductor.

The paper was followed by a second on a similar subject, "Cable-Borers," by Mr. G. E. PREECE. This paper gave an interesting account of the ravages of the "Limnoria terebrans," an abstract of which will appear in our next.

The Chairman announced that at the next meeting, on the 8th December, the Election of President and Officers would take place.

The following candidates were balloted for at the end of the meeting, and declared unanimously elected:—

As Foreign Members—Dr. Fr. Dehms, of the Imperial German Telegraphs, Berlin; Frederick Carl Nielson, Great Northern Telegraph Company, Hong Kong; Carl C. Sonne, ditto.

As Members—George Bird, New Zealand Telegraph Department, Canterbury; Captain F. W. Heneage, R.E., Chatham; Lieut. H. P. Nicholls, R.E., ditto; Lieut. Herbert Rawson, R.E., ditto; Lieut. E. F. Rhodes, R.E., ditto; Sir David Salomons, Bart., Tunbridge Wells; William J. Wilson, F.C.S., Royal School of Mines, South Kensington.

As Associates—Edward Applegarth, Palmerston-buildings; Frantz Jacob, Charlton; William

F. Nosworthy, Western and Brazilian Telegraph Company, Monte Video; Alfred Peters, Western and Brazilian Telegraph Company, Bahia; Wm. Donald Smallpiece, Basingstoke.

ON A CURIOUS CASE OF MAGNETIZATION.

By M. J. JAMIN.

(From the *Comptes Rendus* of the Academy of Sciences, Paris.)

I AM indebted to the courtesy of M. Bertrand for becoming acquainted with a curious cause of Magnetization, observed by Galileo, and described by him in a letter addressed, in 1607, to Curzio Picchena. The letter refers to a very extraordinary loadstone.

"It was so powerful, that on presenting the "point of a scimiter at a distance equal to the "thickness of a silver piaster, it could not be held "back, and even a strong man, pressing the scimi- "ter against his chest could not resist the attrac- "tion. I have discovered in this loadstone another "extraordinary effect which I have never met "with in any other magnet: the same pole both "attracts and repels the same piece of iron. At a "distance of at least four or five inches it attracts "the piece of iron, but at a distance of one inch it "repels it. If the piece of iron is placed upon a "table and the magnet is brought very near it, the "iron is repelled and recedes before the magnet if "the latter is pushed forward; but if the magnet "is drawn back immediately, the distance becomes "four inches, the piece of iron is attracted and fol- "lows the magnet as the latter is drawn away; it "never, however, approaches nearer than one inch."

The stone was purchased by the Grand Duke. Galileo was able to examine it at leisure, and the result of his subsequent experiments proved that the piece of iron previously mentioned was magnetized steel, for the stone attracted soft iron at all distances and raised six pounds weight of the latter. Finally, it had the property of attracting at a distance, and repelling when near the same pole of a bar of steel. The stone was unfortuuately lost.

In the course of my investigations, I have come across (without seeking it) a case of magnetization of the same kind, in which there is no kind of mystery.

I will first of all remark that a bar of steel may be magnetized to saturation by a very powerful current, and to one of the halves may be given a southern magnetization, which I shall call *positive*, and which extends to the very centre or heart of the bar. This being done, I submit the bar to a current in the reverse direction, weak at first, but gradually increasing, which produces a northern or *negative* magnetization, limited at first to the surface but penetrating afterwards to an increasing depth, always leaving, however, layers of positive polarity underneath. The effect observed is but the result of the difference of action of the two magnetizations superposed one over the other, as manifested externally. It is first positive, then neutral, and finally negative. I stop directly the change of sign is apparent.

I afterwards dissolve the steel in acid, and it is evident that I thus remove, little by little, the exterior northern or negative layers, and expose the underlying southern ones; that the magnetization observed is at first negative, then diminishes, becomes neutral, and then changes the sign. These results have been already communicated to the Academy.

I have now to add that the southern layers are not laid bare throughout at the same time. They commence to show themselves at the end, and especially at the edges and corners as points, very sharp, and of very small extent. They have then a great tension, but their magnetic momentum is small, because they occupy a very small surface. At the same time there exists a northern layer extending uninterruptedly from the end to the mean line; this is the remainder of the exterior layers which have not yet been eaten away by the acid. The intensity of the latter is almost nil at any given point, but the surface being large the quantity and momentum of this northern magnetism are considerable, more considerable than the quantity and momentum of the southern points which protrude at the very end; it follows that this half of the bar turns to the south as if these last-mentioned points did not exist.

Let us bring forward gradually the southern pole of an ordinary magnet; whilst it is at some distance, it is subject to the predominant influence of the northern layers of our bar, and is attracted, but if it is brought to the end of the bar, it comes very near to the southern points, which are situated at the end, the force of the latter prevails, and repulsion takes place; thus we have attraction at a distance and repulsion upon contact, exactly as in the case of the loadstone of Galileo; and, what is no less curious, upon contact, repulsion of the extremities which turn to the contrary poles of the earth, and attraction of the extremities which turn to the same side. At a sufficient distance, the direction of the effects changes, and everything takes place in the accustomed order.

APPLICATION OF ELECTRO-MAGNETISM TO RAILWAY WHEELS.

By M. DREYFUS.

ATTEMPTS have been made, during a considerable period, to utilise electro-magnetism in working railways; sometimes directly as motor force, sometimes for brakes, sometimes to increase the pressure of the wheels of locomotives against the rails.

Amberger first* employed electro-magnetism thus as motive force in 1851. In 1865, Bellet and De Rouvre showed to the Société des Ingenieurs Civils a model locomotive, meant specially for postal service, but they had also in view the application of their system to trains. In such cases it is a question of whether zinc or coal is dearer, as fuel.

Amberger also proposed, in 1851, the employment of electro-magnetism for brakes; flat electro-magnets should be made to act, at a given moment, on the rails. This would effect a great saving of wheel-tires, the friction and wearing being on the rails; but the method was never thoroughly tried. The first serious experiment with an electro-magnetic brake was made by M. Achard, who is still continuing his observations, and hopes to bring them to a successful issue.

* This is incorrect; for in 1842 an electro-magnetic locomotive, invented by Davison, was tried on the Edinburgh and Glasgow Railway, and in 1838 Coombs brought over a model of an electro-magnetic locomotive from America.

Increase of the pressure of a locomotive's wheels against the rails would favour the action of friction (the mean co-efficient of friction 0·17, sometimes fully under 0·1); and the drawing power of the locomotive cannot, of course, exceed the friction of the wheels on the rails. An increase of the traction force can be obtained by increasing the weight of the locomotive; but such an increase of dead weight is especially disadvantageous on inclines, and the more so that the weight of the locomotive must be calculated according to the greatest incline present on the line. It has often been attempted, therefore, to help the friction with electro-magnetism, but hitherto without any satisfactory success. A new arrangement for this purpose by a Swiss engineer, M. Burgin, has lately been tried on the North-Eastern Railway, in Switzerland. After a brief historic survey we shall describe it.

The first idea of applying electro-magnetism in this way may have been given by a lecture experiment of Professor Eisenlohr, in Carlsruhe, who made a magnet of a horse-shoe-formed locomotive axle, by winding round it 500 m. copper wire, of 4·5 mm. thickness, so that, when the wire was traversed by a current from twenty Grove elements, the magnet would bear 5000 k. In 1846 Dr. Wright proposed to make the wheels of locomotives magnetic, and estimated that each wheel might thus acquire an attractive force of 1000 k. on the rails; he also remarked that the force of attraction might be rendered variable. There is no record of the proposal having been carried out. When M. Niklés was consulted, in 1851, by MM. Amberger and Cassal, as to a physical means of increasing the pressure of locomotive wheels, he recommended electro-magnetism. In his first arrangement, a horse-shoe electro-magnet was fixed to the body of the locomotive, between two pairs of wheels, its poles were about 4 mm. from the rails. A small model acted well on an incline; the motive force was derived from a weight connected with the axle by a cord passing over a pulley at the top of the incline, another weight was suspended from a cord passing to the locomotive over a pulley at the bottom. Soon after, M. Niklés replaced this electro-magnet by coils enclosing the lower part of each wheel nearly to the rail, each coil 250 m. of copper wire; they were attached to the frame of the locomotive. Good results were had thus with a small model on a changeable incline. Thereafter, similar experiments were made on a 20 per cent. incline, with a pair of locomotive wheels 1·10 m. diameter, and with sixteen battery elements; in dry weather the friction was about 350 k.; the adhesion through electro-magnetism 450 k. (or, supposing the co-efficient of adhesion 0·1, 4500 k.); in damp weather the friction went down to 100, while the electro-magnetic adhesion was weakened only about 50 k. A thick layer of tallow on the wheels brought down the magnetic adhesion to 400 k. The magnetic adhesion, therefore, for each pair of wheels might be estimated at about 1000 k. The expenditure in acid and zinc during ten hours' uninterrupted service was about 11·2 gr. It was thought deducible from the experiments that the velocity of rotation of the wheels did not compromise the magnetic action, but from experiments on the Paris and Lyons Railway the opposite was proved; for in the heavy train, which moved with slow velocity up an incline of 10 in 1,000, scarcely 9 per cent. increase in adhesion was gained. Niklés and Amberger, therefore, gave over magnetising the wheels with such coils.

The cause of non-success of M. Niklés' first arrangement lay in the distance of the magnet from its armature; in his second it lay in the fact that the position of the pole could not shift with sufficient rapidity. During the experiments on the Lyons Railway, M. Niklés thought of magnetising the whole circumference of the wheel, and devised a special arrangement for this purpose; which, however, was never carried into practice.

In 1859 Mr. Gerrel, in America, magnetised the lower part of wheels by an arrangement similar to that of M. Niklés. Each coil contained 823 m. copper wire, No. 8, in 288 windings; the battery consisted of 16 Grove elements, and had a zinc surface of about 1935 sq. c. The steam pressure could be raised 8·6 k. without the wheels slipping on the very smooth rails, but to 15·9 k. if the wheels were magnetised; with good rails even to 22·7 k. and 40 k. Similar experiments were made by M. Black, in 1859.

In 1865 a new arrangement was tried on the Central Railway, in New Jersey. The copper coils, fixed round the tires, on the inside of the wheels, made the two wheels on one axle poles of a single magnet. The experiments, continued more than a year, gave an increase of about 40 per cent. in adhesion. These American experiments were discontinued, because at that time it was not understood how to produce, with a dynamo-electric machine, and comparatively small expenditure of mechanism, very powerful electric currents.

In M. Bürgin's system, the entire axle with its wheels is also turned into a magnet with fixed poles. But he envelops the axle itself with the wire; and with increasing thickness of windings towards the wheels, in locomotives that have external cranks, but with uniform thickness in those with internal. In the case of coupled wheels, the winding is so arranged that there is an alternation of poles, the piece of rail between two wheels forming a closed armature. This mode of winding allows an increase of the number of turns, and, consequently, stronger magnetisation. A small locomotive model (but without engine and boiler), with three pairs of wheels, and external cranks, was placed on a 30 per cent. inclined plane, and the coils were connected by long wires and a commutator with five Bunsen elements. The driving force was supplied by a weight of 12 k., the cord of which passed round the three axles. The wheels of the model (its weight was 8·5 k.) slipped in position, if the weight was allowed to run, and the circuit not closed; hut when the current flowed, the model went up the incline. If the brake of the model was applied, the latter remained in position on the plane while the current was flowing; but on interrupting the circuit, the wheels began to slip on the rails, and the model slid down with increasing speed; when the current was admitted again the model stopped, notwithstanding its acquired velocity. On a plane of 100 per cent. incline, the locomotive could be held fixed only when the current was flowing and the brake applied. On the under side of a horizontal line the model was held by magnetic attraction, moved to and fro, and could even be loaded with 7 k.; the entire attraction was thus 15·5 k. On the

horizontal line, still loaded with 15·5 k., it was moved, with brake applied, by a weight (suspended over pulley) of 7·5 k. The coefficient, of friction was thus:—$F_1 = 7{\cdot}5 : 24 = 0{\cdot}312$. After removal of the 15·5 k. load, and application of the brake, the model was first moved by 10 k. The coefficient of friction was thus:—$F_2 = 10 : 24 = 0{\cdot}416$. The proportion of the two was $F_1 : F_2 = 312 : 416$, and even with wet rails, it continued the same.—(*Iron*).

A NEW RELATION BETWEEN ELECTRICITY AND LIGHT: DIELECTRIFIED MEDIA BIREFRINGENT.*

By JOHN KERR, LL.D., Mathematical Lecturer of the Free Church Training College, Glasgow.

(From the *Philosophical Magazine*.)

THE thought which led me to the following inquiry was briefly this:—That if a transparent and optically isotropic insulator were subjected properly to intense electrostatic force, it should act no longer as an isotropic body upon light sent through it. Faraday was often occupied with expectations of this kind; and he has mentioned in his memoir on the Magnetization of Light, and elsewhere in his "Researches," how he experimented in this very direction, upon electrolytes as well as dielectrics, at different times and in many ways, but always without success†. As far as I remember, I have not read or heard of an attempt in this field by any other naturalist. I proceed to offer a few notes of some recent experiments of my own. The investigation is not so complete as I should wish it to be; but it has been carried forward as far as my limited time and means would allow. At present I confine myself to solid dielectrics, reserving the case of liquids for a second paper. The principal results given in this first paper are stated apart, in articles 11, 17, 23.

1. *Dielectric of Plate Glass.*—A piece of good plate glass, $\frac{3}{4}$ inch thick, is formed roughly, before it leaves the shop, into a rectangular block 6 inches long and 2 wide. In this and subsequent operations, the original polish of the plate is carefully preserved. Two holes, about $\frac{1}{10}$ inch wide, are drilled into the block from its opposite ends; they lie exactly as in continuation of each other, in a line parallel to the longest edges of the block, and midway between opposite faces; and they terminate in well-rounded bottoms at the centre of the block, with a short extent (a quarter inch or less) of clear glass between them. Two fine pillars of glass rise from a stand on the table, distant an inch or two from each other. The block is placed across the pillars (at about a foot from the table), its plate-faces vertical, and the line of borings horizontal; and in this position it is tied securely to the pillars by coils of silk thread. Two thick wires of copper, sheathed in guttapercha, have their bare extremities inserted in the borings, down to the ends. As a provision against the strongest electric action applied in any case, these wires are coated very deeply with lac or sealing-wax at their junction with the glass, and an inch or more outwards. The whole surface of pillars and block is well varnished with lac—except a small space which is left clean upon each of the plate-faces, to allow distinct vision through the centre of the block.

When the dielectric has been thus prepared, its transparency is all that can be desired. Objects bright or faint are seen horizontally through the central parts of the plates (between and around the ends of the borings) quite as well as through a fine window.

2. The electricity is obtained from a Ruhmkorff's induction-apparatus, which gives a spark of 20 to 25 centimetres. The dielectric just described stands upon the table close to the inductorium. The outer ends of the wires from the dielectric are screwed into the knobs of the secondary coil. From the same knob two wires are led to the other side of the instrument, and are connected with two insulated metallic balls, which act as spark-terminals. The distance of these balls, or the actual spark-length in air, is under the observer's control at every instant.

The ends of the secondary coil are separated thus at one place by so many inches of air, and at another place by a quarter inch of glass. When the primary circuit is closed in the usual way, through the oscillating rheotome of the instrument, the air between the spark-terminals is broken by a sensibly incessant discharge, while the glass between the induction-terminals is traversed by a strong electric force. By simple increase or diminution of the distance between the spark-terminals, the intensity of electric strain thus produced at the centre of the glass block may be raised or lowered at once, and in any degree, as the observer pleases. I may mention that on several occasions, when the instrument was working at full power and the spark-terminals were drawn $7\frac{1}{2}$ or 8 inches apart, strong discharges burst across between the two induction-wires, at the rate of about one per second, without cessation of the principal discharge. The insulation was so good that the dielectric was not in any way damaged. The discharges took place through the air in dense white sparks, from end to end of the block, a distance of 7 or 8 inches. In these circumstances, the part of the glass block between the induction-terminals must have been subjected to a strain little short of the utmost it could bear. Electric forces of such intensity were hardly ever applied in the experiments, were not indeed required.

3. The polariscope consists of two Nicol's prisms. A flat paraffin flame, presented edgeways, is used as a source of light. Next to the lamp, and close to it, comes the first Nicol; then at a distance of 2 feet or more comes the dielectric of plate glass; then at a like distance comes the second Nicol. The pieces are so arranged that the observer, looking horizontally through the polariscope, and keeping the first Nicol at the centre of the field of vision, sees the flame through the centre of the dielectric, midway between the induction-terminals. The light crosses the dielectric at right angles to the plate-faces, and therefore at right angles to the lines of force.

4. *Neutralizing Plate.*—Every very thick plate of glass which I have yet worked with exerts at most of its points a slight depolarizing action upon transmitted light. When such a plate is inserted

* Faraday's "Experimental Researches," 2216, p. 951, or Maxwell's "Treatise on Electricity," vol. ii. p. 399.

between the two Nicols without compensation, anything like perfect extinction is generally unattainable, and the sensibility of the polariscope is lost.

The principal section of the first Nicol being in any desired position, and that of the second Nicol perpendicular to it, the dielectric (still unexcited, though connected with the coil) is inserted properly between the Nicols, and the light reappears well in the polariscope.

The neutralizing plate, a piece of glass about 6 inches square, taken from the same original plate as the dielectric, is then placed upon a stand immediately in front of the second Nicol, and is moved by trial into such a position that the restored light is again extinguished perfectly by a very small rotation of the analyzer. The apparatus is now ready for work.

5. The highest powers applied in the experiments are sufficiently indicated thus:—Battery in the primary circuit, a series of six Grove's or Bunsen's elements; corresponding spark-length, 9 or 10 inches; actual spark-length, or thickness of air between the spark-terminals, 6 inches, rarely 7; thickness of glass between the induction-terminals $\frac{3}{16}$ inch. But powers a good deal lower give effects distinct enough.

6. *First experiment.*—The pieces are arranged in the order and manner just described (2, 3, 4). The spark-terminals are fixed at a distance of 5 or 6 inches; the polarizing Nicol is laid with its principal section at 45° to the horizon; and the analyzer is turned, with the help of the neutralizing plate, into the position of perfect extinction. No piece of the apparatus is now touched, except the commutator, till the end of the experiment.

Looking through the polariscope, the observer closes the primary circuit. In about 2 sconds the light begins to reappear through the dielectric, at its old place between the induction-terminals, very faintly at first; but it brightens continuously for 10, 20, even 30 seconds, till it is almost brilliant. When the primary circuit is now broken by the commutator, the light fades away continuously, at first rapidly, then more slowly, to perfect extinction. The time that elapses (in the latter part of the experiment) between the opening of the primary circuit and perfect extinction in the polariscope depends very noticeably upon the intensity and duration of the electrification, increasing as these increase.

7. The light thus restored by electric action cannot be extinguished again, at any stage of the experiment, by any rotation of the analyzer either way.

8. *Second experiment.*—The polarizing Nicol is laid with its principal section either horizontal or vertical; the analyzer is turned into the corresponding position of perfect extinction; all the other arrangements and the procedure are as in the first experiment. There is now no regular effect obtained in the polariscope. In many cases, indeed, even when the strongest electric action (5) has been kept up for 20 or 30 seconds, any recovery of the light is very doubtful, rather a guess than a perception.

Small effects do sometimes present themselves; but they are trifling and irregular in comparison with those obtained in the first experiment. They are probably due to known causes, such as imperfection of adjustments, irregularities of molecular structure in the dielectric, possibly also slight changes of temperature. If a small and irregular allowance be made for one or more such disturbing influences, there is now no effect in the polariscope.

9. *Third experiment.*—Distance of the spark-terminals small (say, 2 inches), the arrangements otherwise as in the first experiment. The electric action is kept up for a minute or more, till the intensity of the restored light is certainly constant. The spark-terminals are then separated all at once to a distance of 6 inches, and in a second or two there is an evident increase of effect in the polariscope. Simple arrangements will be described soon, which exhibit this increase of effect as a reappearance from extinction.

10. *Fourth experiment.*—The same as the first, except that the primary current, instead of being constantly in one direction, is regularly reversed by the commutator at successive equal intervals of time (say, every second). The optical effect is as good as in the first experiment, if not better.

11. *Summary.*—When plate glass is intensely dielectrified, and traversed by polarized light in a direction perpendicular to the lines of force, it exerts a partially depolarizing action upon the light, giving an effect which is much more than merely sensible in a common polariscope. There is a good regular effect when the plane of polarization is at 45° to the lines of force, no regular effect when the plane of polarization is parallel or perpendicular to the lines of force. Electric force and optical effect increase together. The optical effect of a constant electric action takes a certain time (apparently about 30 seconds in my observations) to reach its full intensity, which it does by continuous increase from zero; and it falls again slowly to zero after the electric force has vanished. There is as good an effect with a rapid succession of contrary (Ruhmkorffian) electrizations as with a continued (Ruhmkorffian) electrization in one direction.

12. *Optical Compensator.*—Not having a regular instrument of this kind, I supply its place by a simple slip of glass held in the hands and subjected to varying stress. The action of strained glass upon transmitted light has been exactly determined by experiment. Compressed glass acts as a negative uniaxal crystal with its axis parallel to the line of compression; stretched glass acts as a positive uniaxal with its axis along the line of tension.

Illustrative optical experiment.—All the pieces placed as in the first experiment (2, 3, 4), the plane of polarization at 45° to the horizon, the extinction in the polariscope perfect, and the dielectric always unexcited. Two additional pieces are introduced into the course of the beam—say, between the dielectric and the neutralizing plate. The first is a small square of thin plate glass, held edgeways in a vice with its surfaces perpendicular to the beam, and feebly compressed in the direction of its length, which is horizontal. When this piece is inserted, the light is well restored from extinction. The second piece is the compensator—a rectangular slip of plate glass, shaped like a common microscopic slide, but generally larger. It is held by the two hands in front of the neutralizing plate, with its surfaces perpendicular to the beam, and its long edges horizontal; it is

gently bent by the hands, the axes of the couples applied being perpendicular to the plate-faces, so that (say) the upper parts of the slip are extended horizontally, and the lower parts compressed; and it is lowered or raised so that the light, after traversing the first piece, is transmitted to the analyzer through the upper or lower parts of the second piece. Through the extended parts the light is weakened, and, with a right degree of tension, extinguished perfectly, and with a greater tension restored again; through the compressed parts it is always strengthened.

Generally, when the directions of stress in the two pieces are parallel, compression and tension counteract each other; two compressions or two tensions reinforce each other. When the lines of stress are at right angles, two compressions or two tensions counteract each other; compression and tension strengthen each other.

The action of a strained piece in the polariscope is most distinct when the direction of the stress lies, as it does here, midway between the principal sections of the two crossed Nicols. There is no action when the direction of stress lies in either of these planes.

There are several variations of the illustrative experiment that ought to be noticed here for their bearing on what follows. The first piece may be stationed on the other side of the dielectric; it may even be removed altogether, and the compression or tension applied to the dielectric plate itself in a horizontal direction perpendicular to the beam; the results are then the same as formerly. It appears thus, without reference to theory, that horizontal compression of the first piece has always to be compensated in the same way (that is, by horizontal tension of the second piece), whether the first action is applied before the dielectric, or behind it, or in it.

The illustrative experiment takes its simplest form when dielectric or neutralizing plate are both removed. It appears thus that horizontal compression of a first piece has to be compensated in the same way (that is, by horizontal tension of a second piece), whether the other two mutually balanced pieces, the unexcited dielectric and the neutralizing plate, are present or absent. Accordingly, and without reference to theory, in proceeding to characterize the birefringent action of the excited dielectric by means of the compensating slip, I assume that the mutually balanced actions of unexcited dielectric and neutralizing plate are without effect, and therefore to be left out of account.

13. The compensating slips used in the following experiments were of different sizes. But there was one which I came at last to employ almost exclusively, as I found it well adapted to the whole range of effects examined. It was a rectangular piece of very good plate, $\frac{1}{16}$ inch thick, 2 inches wide, and 10 long. It had no sensible action in the polariscope while unstrained.

(To be Continued.)

MAGNETISM OF STEEL.

As Influenced by its Carbon and its Hardness.

For the measurement of the magnetism which different varieties of steel are capable of receiving, according to the carbon they contain and their degree of hardness, M. Trève (*Comptes Rendus*, abstracted by Stummer's *Ingenieur*) had fifteen steel rods prepared, which he grouped into five rows of three each. Each group had a varying proportion of carbon, viz., A 0·950 per cent.; B 0·550; C 0·500; D 0·450, and E 0·250 per cent. The rods in each group received a different hardening: No. 1 was heated up to 767 deg. C., and hardened in water of 10 deg.; No. 2 was heated to 800 deg., and hardened in water of 100 deg.; No. 3 was heated up to 776 deg., and hardened in oil of 10 deg. The rods were magnetised to saturation, and their magnetism measured. The results of these measurements are given in a table, from which we make the following deductions.

Rod A, with hardening No. 1, gave the highest magnetism, viz., forty-seven; with hardening No. 2, the magnetism measured forty-four; with No. 3, it measured forty-three. A comparison of rods A and E, both at hardness No. 1, show the great influence of the carbon, since, while the magnetism of A was forty-seven, that of E was only thirteen. The influence of the hardening is small when the proportion of carbon is large, but becomes more manifest as the proportion of carbon decreases. The measurements show with precision the influence of the proportion of the contained carbon; the magnetism rising with it, as shown by the following table:—

A_1	47	B_1	45	C_1	42·5	D_1	33·5	E_1	13
A_2	44	B_2	30	C_2	30	D_2	22	E_2	10
A_3	43	B_3	37	C_3	37	D_3	29	E_3	12

M. Trève has constructed curves according to these values, showing these results more plainly. A comparison of these curves with the curves of elasticity of these steels shows that as the carbon gives steel its elasticity, it bestows upon it also its magnetic capacity.

To Correspondents.

Learner.—We do not answer enquiries from correspondents who do not affix their names and addresses.

Student.—Ferguson's Electricity is one of the best books for the beginner. He should carefully make every experiment himself. We shall probably review Professor Guthrie's new book in our next number.

A.B.C.—Yes; just so.

*** Duly authenticated contributions, theoretical and practical, on every subject identified with the interests to which "The Telegraphic Journal" is the organ, will always command attention. Anonymous correspondence will be wholly disregarded. Literary communications and books for review should be addressed to the Editor; business communications to the Publishers, 10, Paternoster Row, E.C.

Flashes, like Auroras, are said to have been seen over the dark atmosphere of Venus.

Carbonate of Ammonia reduces the resistance of water considerably, but Ammonia itself does not.